Output Risk in Tuscan Agriculture in the Late 19th and Early 20th Centuries *

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Abstract We analyse output risk in Italian agriculture over the period 1870-1914. We use data on a set of 16 tenanted plots grouped into three farms comprising a single large estate. We estimate the degree of risk associated with each separate crop, with the portfolio of crops at the level of the plot, the farm and the estate. We highlight two particular features: the relatively high risk associated with tree crops (wine, oil and nuts); and the substantial scope for the landlord to reduce risk through crop diversification across plots. We discuss the implications of these for tenure contract theory.

Keywords Output risk, agriculture, tenure contracts, Tuscany

JEL Classification C23, C25, N53, Q15

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1 Introduction

Farming is risky, in the sense that outcomes are strongly affected by unpredictable exogenous factors beyond the control of farmers. Especially in poor economies, where farmers have little access to developed insurance and credit markets, risk plays a central role both in the choice of crop mix and in the institutional arrangements in agriculture, which affect productivity and welfare. The measurement of risk, however, is difficult, because we seldom have the kind of detailed observations that would allow us to separate the impacts of influences such as weather, farmers' skills, access to other inputs, biological factors, and the like. This paper is intended as a first part of a larger project to measure risk in a pre-industrial agriculture. The chosen area, the central Italian region of Tuscany before World War I, is rich in long term agricultural data, because its tenure system, sharecropping, required detailed accounts, many of which have survived. The question we are asking, at this stage, is simple: what was the level of risk faced by farmers in a Mediterranean area? How might this have affected institutions and crop mix?

2 Background and Data

In this section we provide some background in order to place our data in a historical context, first presenting the debate on Italian agriculture during the 19th and early 20th centuries, and second discussing the data used in our analysis.

2.1 Tenancy and Agriculture in Early 20th Century Italy

The conventional view holds that Italian farming was dominated by inefficient and backward tenure systems, such as sharecropping, which distorted incentives and led to suboptimal allocative decisions. In recent years, however, economists have argued that this view is empirically unproven, and evidence to the contrary has been presented.

The two main features of the Italian economy in the years before World War I are its fundamentally agrarian character (in 1911 farming accounted for 55.5 percent of the labour force, and 46 per cent of GDP (Fenoaltea 1983, Toniolo 1990)), and its dualistic nature, with a relatively rich industrial North and a poor agrarian South. Before 1914, Northern regions had *per capita* incomes and productivity between 2.5 and 5 times greater than the South's (Federico 1996, Galassi and Cohen 1992, Zamagni 1978), a gap that has not shown a tendency to shrink (Zamagni 1993).

Dualism and the persistence of a large agrarian sector are the main themes of modern Italian economic history. Gramsci (1950) and Sereni (1946, 1947) argued that at the time of political unification (1861), 'modern' agrarian institutions only existed in Northern Italy, where the preconditions were set for agricultural growth and eventually industrial development. On the contrary, in central and Southern Italy, 'feudal residues' discouraged productivity-enhancing investments and kept the peasantry in a state of poverty and subjection to rural lords. As the issue of tenancy systems is central to our paper, it is worthwhile discussing these arrangements in some detail.

The conventional wisdom holds that pre-1914 rural Italy can be divided in three areas. In the North, farming was a market oriented business run by landowners with salaried workers, or by rich tenants paying fixed rents. Share tenants were common in some areas in the North but were usually well off peasants who could supply their own draft animals and tools (Poni 1982). In central Italy, where share contracts were by far the most common tenure system, croppers were usually poor and unable to supply capital equipment. Farms were small and intensively cultivated, but little machinery was used. Further South, roughly from Rome down, large latifundia were leased by an indolent and absenteeist aristocracy to middlemen who then sublet to small peasants or hired landless labourers at peak times. Agriculture in the Centre and South was thus starved of capital, as evidenced by its low productivity and primitive techniques. Hence, the conventional story goes, the backwardness of Italy's economy, and in particular the poverty of the South.

Modern research has cast a great deal of doubt on this view. Recent work (Bevilacqua 1990, Lupo 1990, Galassi and Zamagni 1994) has shown that both landlords and peasants in the South were willing to innovate and take risks under the right conditions, introducing new crops and adjusting their crop mix when the market provided adequate incentives. Further, the view of tenurial arrangements as ‘feudal residues’ has been seriously undermined. The institutions of rural Italy have been reassessed by Cohen and Galassi in a series of papers approaching tenure choice as an agency problem under objective constraints (1990, 1992, 1994; Luporini and Parigi 1996 for formal modelling). Their examination of factor proportions and productivity for sharecropping areas in central Italy suggests that productivity differences had more to do with the environment in which farmers were operating than institutional problems. Cost benefit analysis of capital investments on sharecropped farms has revealed that delayed mechanization in central Italy was due not to tenure arrangements but to relative factor prices (Galassi 1993). Moreover, the South, long pictured as a land dominated by large estates worked by wage labour, turns out to contain contractual arrangements of much greater variety and intricacy. We would argue that these tenancy relationships represented rational responses by landlords and tenants to the problems of high income variance, incomplete or non-existent credit and insurance markets, adverse incentives, and delicate cash crops.

In the North, where the climate allowed farmers a wider range of crop and livestock choice, diversification was effective as a risk-management technique. Small scale credit was also easier to come by, and evidence suggests that at all events crop yields in Northern Italy were less variable than in the hot and dry Centre and South (Galassi and Cohen 1994). Relatively low risk and weak agency problems not surprisingly were associated with fixed rent or wage contracts. Similar motivations explain why fixed rent and wage contracts in the South were linked with grain growing, except that greater exogenous risks there forced farmers to diversify by entering into multiple contracts. Share tenancy in the Centre and South was associated with tree crops, while in the North share tenants were more often farmers who had access to some non-tradeable input. The difference between the sharecropped farms in the Centre and the crop-specific share contracts common in the South can also be explained as diversification, as in the riskier environment of the South sharecroppers preferred to farm scattered plots rather than take on a single farm as in the Centre.

The case for the reassessment of the traditional story rests largely on the assertion that important items in the Mediterranean crop mix were subject to particularly strong exogenous influences. The measures of risk previously used to support this (Galassi and Cohen 1994, 590), suggestive though they may be, are undeniably crude. In this paper, we use an adaptation of the approach used in financial analysis for the assessment of risk, to give a better picture of the risk characteristics of the agricultural estates typical of 19th century Tuscany.

2.2 The Data.

The advantage of share contracts from the perspective of the historical economist is that they require both parties to keep accurate accounts. Especially where landownership was concentrated, as in Tuscany, and landlords used hired managers, the account books of numerous farms have survived, so that precise records exist for long periods of time. By the 19th century, individual sharecropped farms (*poderi*) belonging to large landlords were usually grouped together in a central organisation called a *fattoria*. The *fattoria* in effect functioned as an administrative body, monitoring individual tenants and keeping accounts for each individual *podere*, and as an implements pool, purchasing expensive or indivisible capital inputs such as threshing machines. It is from the account ledgers of three Tuscan *fattorie* from 1870 to the Great War that all data used in this work were obtained. In order of size, they are: *Cerbaia*, 372 ha, near Sovicille, 15 km west of Siena; *Macereto*, 315.8 ha, near Casciano di Murlo, in the clay soils 25 km south of Siena; and *Poggio le Rose*, 25.5 ha, in Costafabbri, 5 km south west of Siena.

Situated in the heart of Tuscany, these farms were selected because they represent three types of terrain common throughout central Italy. *Cerbaia* is located in wooded hills some 60 km inland, in an area of intensive cultivation over difficult ground, where temperatures drop dramatically in winter. *Macereto* is in undulating country with dense clay soils where a relatively extensive form of farming was practised. *Poggio le Rose* is a small farm just outside the city limits, in an area of dense settlement and intensive agriculture. The three farms were administered by the same manager over this period, and their ledgers are kept in the State Archive in Siena (ledgers for 1900 and 1909 are missing). Our chronology reflects the need to have a sufficiently long time period undisturbed by wars and political upheavals before the introduction of machinery in the post-1945 years.

The *fattoria* ledgers were organised in three parts. The first recorded the landlord's share of output produced over the accounting period, the seed distributed, revenues from sales, and expenditures. The division of output occurred after the seed for the next season had been set aside, so the quantities reported here consist of twice the output recorded in the accounts plus seed. The second part of the account books reported statements of outstanding debt or credit between tenants and landlords, and the third dealt with livestock on each *podere*. The reliability of ledger entries is usually reckoned to be very good.

All *poderi* on these farms were continuously leased with share contracts in the period under consideration, with the exception of *Terre a Mano* in the *Macereto* farm, where wage workers were used. While over time some *poderi* were sold or bought, we have focused our analysis on those 16 *poderi* for which we have an uninterrupted run of observations (8 in the *Cerbaia* farm, 5 - including the plot farmed with wage workers - for *Macereto*, and 3 for *Poggio Le Rose*). Each of these produced a variety of crops, on average between 8 and 10. For all annual crops (except maize) we have information on seed distributed annually to the sharecroppers. We do not, however, have a way of measuring how much land was used for trees (grapevines, olive trees, mulberries for silkworms, fruit trees) which formed an important part of these farms' total output, nor do we know what proportion of the farm consisted of wooded areas (most relevant for *Cerbaia*). Some products that were probably important in the sharecroppers' economy (poultry, eggs, products of vegetable gardens, charcoal) were not recorded by the farm administration, since the landlord did not receive a share. The variability of the croppers' incomes may thus appear somewhat distorted in our calculation, but there is no way of judging whether this is by excess or defect. Sharecroppers, in any event, tended to consume most of their share of the output rather than selling it on the market.

3 An empirical analysis of output risk

The output from agricultural activity represents an uncertain return on a substantial capital investment in land, seed, etc. As with any other risky investment prospect, risk can be controlled to some extent by means of diversification. The greater extent of diversification available to landlords owning large estates, than to tenants depending on the working of a small *podere*, is an issue relevant to many aspects of agriculture. In particular, risk-sharing has long been recognised as a possible motivation for the widespread use of sharecropping contracts. In the absence of risk, sharecropping is sometimes seen as an inefficient system which weakens tenants' economic incentives by imposing an arrangement equivalent to an output tax. In an earlier article, dealing with Tuscan agriculture in the fifteenth century, we found that sharecropping was particularly important for plots producing wine and olive oil, both of which are crops produced from long-lived capital goods (vines and olive trees). A possible alternative explanation for the persistence of sharecropping was given, based on two institutional and technical features: that enforceable long-term tenure contracts could not be made (since tenants always had the right to leave); and that vines and trees were vulnerable to damage from cultivation patterns producing high short-term output, at the expense of the long-term value of the underlying capital goods. In this context, the output tax implicit in sharecropping could have the beneficial effect of deterring opportunistic short-term behaviour.

It is difficult to distinguish between the risk-sharing and opportunism models without having a clear picture of the relationship between risk and output mix, and also the relative degrees of risk borne by tenants and landlords under alternative tenure contracts. This latter issue depends on the landlord's scope for reduction of risk by means of output diversification. In the institutional structure of sharecropping in this region, crop choice was in the hands of the landlord, who (or whose agents) stored the seed and distributed it to the tenants. The landlord may then be expected to have pursued an estate-wide diversification strategy, spreading the crop portfolio across *poderi*. Two constraints limited his freedom of choice in any given year, however, one technical and one institutional. First, the fact that a large proportion of the estate's (and each *podere*'s) output was produced by tree crops with long lead times and high sunk costs meant that rapid adjustments of the portfolio were not feasible. Secondly, because tenants relied on the produce of the plot for their subsistence, the landlord could not avail himself of his full discretionary power over crop choice without incurring resentment and opposition. In part this could be mitigated by acting to smooth consumption over time for tenants who fell into arrears, but this was hardly an attractive option if tenants were then unable to settle. The expectation then is that the crop mix would change slowly over time.

3.1 A framework for the analysis of output risk

Define the following notation. $Y_{pf}^{c}(t)$ is a measure of the output of the *c*th crop produced by the *p*th *podere* in *fattoria f*, during year *t*, where $c = 1 \ldots C$. $X_{pf}^{c}(t)$ is a corresponding vector of systematic, predictable influences on the output, including land, labour, seed and other inputs allocated to the crop, and external conditions conditions such as the tenant's ability, and the predictable component of local climate. The technology is assumed to be as follows:

$$y_{pf}^{c}(t) = m\left(X_{pf}^{c}(t)\right) + r_{pf}^{c}(t) \tag{1}$$

where $y_{pf}^{c}(t)$ is the natural log of output[1] $Y_{pf}^{c}(t)$, $m\left(X_{pf}^{c}(t)\right) = E\left[y_{pf}^{c}(t)\middle|X_{pf}^{c}(t)\right]$ is the predictable component of output, and $r_{pf}^{c}(t) = y_{pf}^{c}(t) - m\left(X_{pf}^{c}(t)\right)$ is the random or risky component of output. Note that, if $m\left(X_{pf}^{c}(t)\right)$ can thought of as the sum of two components: the (log) of an initial investment of resources, $\overline{m}^{c}$; and a remaining component reflecting the systematic part, $\overline{r}^{c}$, of the return on that investment. Defining $\overline{M}^{c}$ as $e^{\overline{m}^{c}}$, we can then write:

$$\frac{Y_{pf}^{c}(t)}{\overline{M}^{c}\left(X_{pf}^{c}(t)\right)} = e^{\overline{r}^{c}\left(X_{pf}^{c}(t)\right) + r_{pf}^{c}(t)} \approx 1 + \overline{r}^{c}\left(X_{pf}^{c}(t)\right) + r_{pf}^{c}(t) \tag{2}$$

In this sense, $r_{pf}^{c}(t)$ can be viewed as the unpredictable part of an approximate rate of return on assets employed.

Our objective is to analyse the extent of output risk at the level of the individual *podere*, the *fattoria* and the estate as a whole, and to assess the way that the allocation of risk between landlord and tenants is influenced by crop mix and diversification. As our basic indicator of risk, we use the conventional notion of volatility, defined as the standard deviation of the unpredictable component of the return on assets invested. At the level of the individual crop and *podere*:

$$s_{pf}^{c} = \sqrt{\operatorname{var}\left(r_{pf}^{c}\right)} \tag{3}$$

[1] Output is measured here in value terms, with outputs valued at the average (over the whole period) of the accounting prices used in the *fattoria* records. True market prices are not available, so our analysis necessarily abstracts from price risk. Of course, even if actual crop prices were available, so that we could conduct the analysis in terms of the risk associated with nominal farm income, there would still remain an element of risk associated with unpredictable local variations in real income stemming from the general consumer price level which might be correlated with variations in farm yeilds.

The total output of an agricultural unit is analogous to an investment portfolio, with potentially different returns on each of the constituent crops. Since all crops are affected to some extent by a common set of weather and husbandry conditions within any one year, there is likely to be some covariation of the returns on different crops. If the covariances are large and positive, then there will be little scope for risk reduction by diversification, whereas if the covariances are small (and particularly if they are negative), landlords with large diversified crop portfolios will benefit from substantially reduced output risk. The total output risk for any particular *podere* depends on two factors: the crop mix and the matrix of contemporaneous covariances between the returns on different crops. The crop mix is represented by a $C\times1$ vector m_{pf} of crop loadings, whose cth element is defined as $\overline{M}_{pf}^{c} \Big/ \sum_{d=1}^{C} \overline{M}_{pf}^{d}$ The covariance matrix of returns is $\Omega_{pf} = \left\{ s_{pf}^{cd}, c, d = 1 \ldots C \right\}$, where s_{pf}^{cd} is the covariance between $r_{pf}^{c}(t)$ and $r_{pf}^{d}(t)$. The index of total output risk is then:

$$s_{pf} = \sqrt{\operatorname{var}(m_{pf}' r_{pf})} = \sqrt{m_{pf}' \Omega_{pf} m_{pf}} \tag{4}$$

where r_{pf} is the $C\times1$ vector of random crop returns.

Analogous risk measures can also be defined at the *fattoria* and estate levels. For a particular *fattoria f*, containing n_f individual *poderi*, the vector of portfolio shares, $m_{.f}$, is $Cn_f\times1$ and is defined as:

$$m_{\cdot f}' = \frac{1}{\sum_{p=1}^{n_f} \sum_{c=1}^{C} M_{pf}^{c}} \left[(M_{1f}^{1} \ldots M_{1f}^{C}) \quad . \quad . \quad . \quad (M_{n_f f}^{1} \ldots M_{n_f f}^{C}) \right] \tag{5}$$

The corresponding covariance matrix of returns is:

$$\Omega_{\cdot f} = \begin{bmatrix} \Omega_{1f} & \mathrm{P}_{12}^{f} & . & . & \mathrm{P}_{1n_f}^{f} \\ \mathrm{P}_{21}^{f} & . & . & & . \\ . & . & . & . & . \\ . & & . & . & \mathrm{P}_{n_f-1,n_f}^{f} \\ \mathrm{P}_{n_f 1}^{f} & . & . & \mathrm{P}_{n_f,n_f 1}^{f} & \Omega_{n_f f} \end{bmatrix} \tag{6}$$

where P_{pq}^{f} is the $C\times C$ matrix of covariances between the crop returns on the pth and qth *poderi* within *fattoria f*. The risk for *fattoria f* is then:

$$s_f = \sqrt{m_{.f}' \Omega_{.f} m_{.f}} \tag{7}$$

An analogous expression is used to construct the risk measure for the whole estate. In that case, with 16 *poderi* used in the calculations, and potentially 15 different crops, the order of the loading vector and covariance matrix is 240.

3.2 Estimates

In implementing this approach to risk measurement, we are faced with the problem that both the covariance matrices Ω and the loading vectors *m* are unknown and must be estimated. The risk indices could be estimated straightforwardly if data were available for the vectors r_{pf}. However, these are not observable, and must be constructed as the residuals from some form of regression relationship used to approximate the systematic part of the relationship (1). This is not a simple matter; the regression function $m\left(X_{pf}^{c}(t)\right)$ represents the variations over time in the land allocated to each crop, the amount of seed and fertiliser used, labour and capital inputs and the state of knowledge and technology. Most of this complex of factors is not recorded in the farm ledgers, and only a simple approximation to $m\left(X_{pf}^{c}(t)\right)$ is therefore possible. Fortunately, our sample period was one of stability and relatively slow change in the character of Italian agriculture. Apart from a few cases of periods when particular crops were discontinued on particular *podere*, there is no obvious evidence in the output or seed series of major shifts in the allocation of land to individual crops, within *poderi*. With 16 *poderi* and up to 15 crops one each, it is not feasible to show all the output series graphically. However, figures 1-3 show the outputs of the main crops on three representative *poderi*: Casanova in the Cerbaia *fattoria*; Palazzo (Macereto) and Poggio le Rose (in the *fattoria* of the same name).

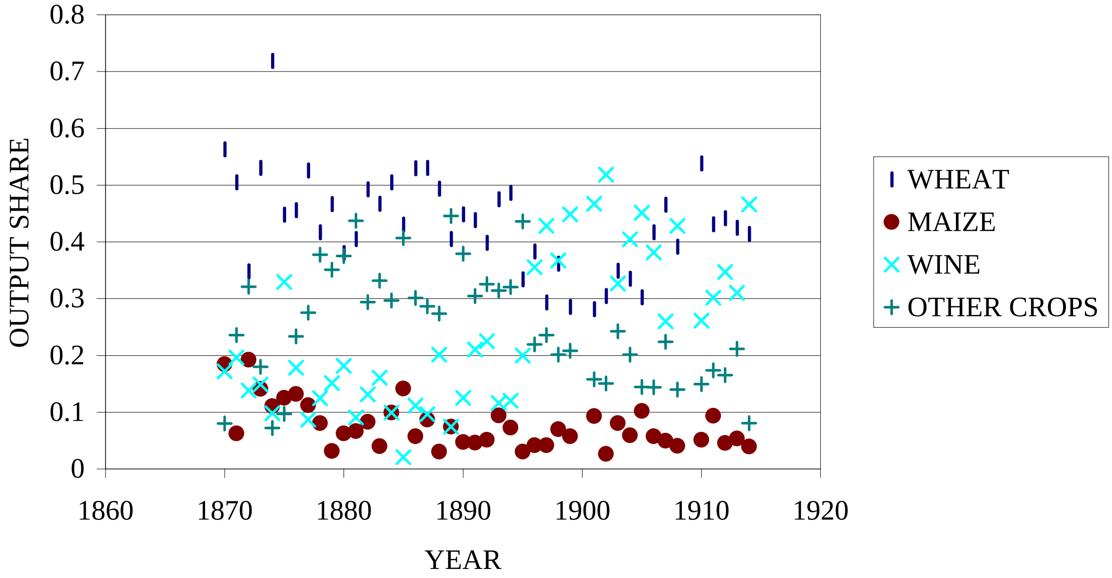

Figure 1 Output shares for the Casanova (Cerbaia) *podere*

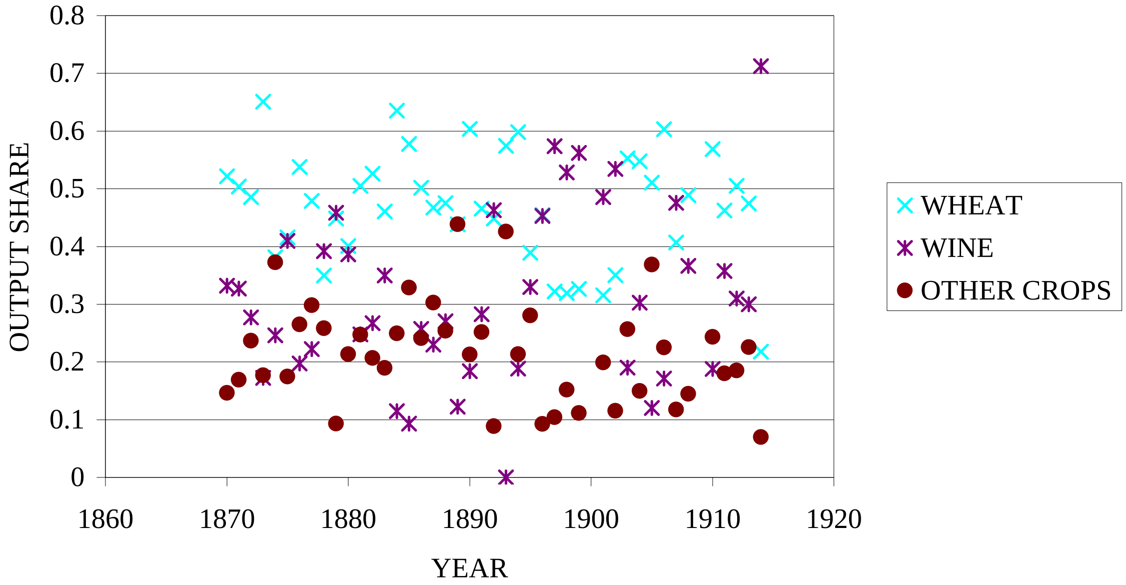

Figure 2 Output shares on the Palazzo (Macereto) *podere*

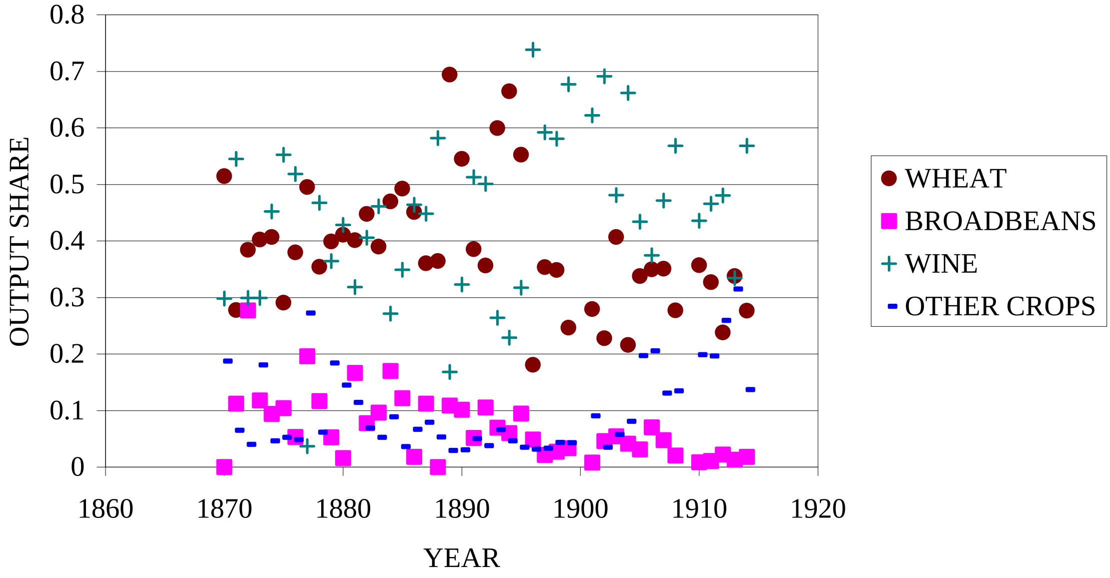

Figure 3 Output shares for the Poggio le Rose *podere*

Four sets of estimates were produced, using alternative approaches to the estimation of the function $\mu(t)$ and indicators of yield. The four approaches are as follows:

i. Linear regression of log output on a constant and time.

ii. Linear regression on a constant and time of a dependent variable defined as the log of *either* output divided by seed (for the five crops wheat, oats, vetches, beans and broadbeans) *or* output (for all other crops).

iii. A non-parameteric regression of log output on time, using the Nadaraya-Watson kernel estimator, with a Gaussian kernel and bandwidth h=5 (see Härdle, 1990; Pudney, 1993). Heuristically, this amounts to estimating the height of the regression function at any date, using a smooth local averaging procedure in which 90% of the weight is given to observations within 16 years or so of the year in question.

iv. A non-parameteric regression on time of a dependent variable defined as the log of *either* output divided by seed (for the five crops wheat, oats, vetches, beans and broadbeans) *or* output (for all other crops). The Nadaraya-Watson kernel estimator was used, with a Gaussian kernel and bandwidth h=5.

These alternative approaches produce differing estimates, but a common pattern emerges. For the sake of brevity, we reproduce here only one set of results: those for the non-parametric trend regression applied to log output (approach (iii)), but these are broadly representative of the other methods also. To give an idea of the ability of nonparametric regression to capture nonlinear trends in the output data, figures 4 and 5 show the estimated trend and raw data for two cases: wheat and wine for the Casanova *podere* at Cerbaia.

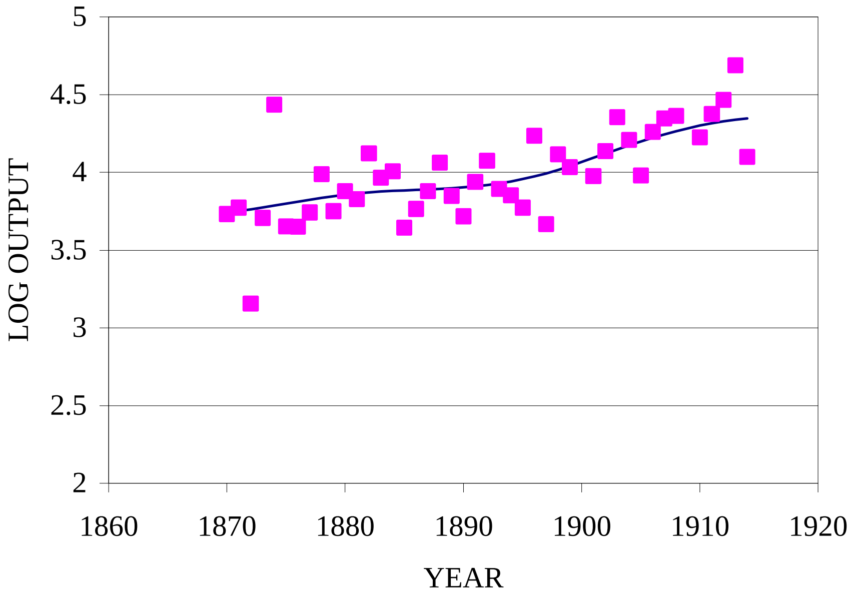

Figure 4 Actual and fitted log output of wheat at Casanova (Cerbaia)

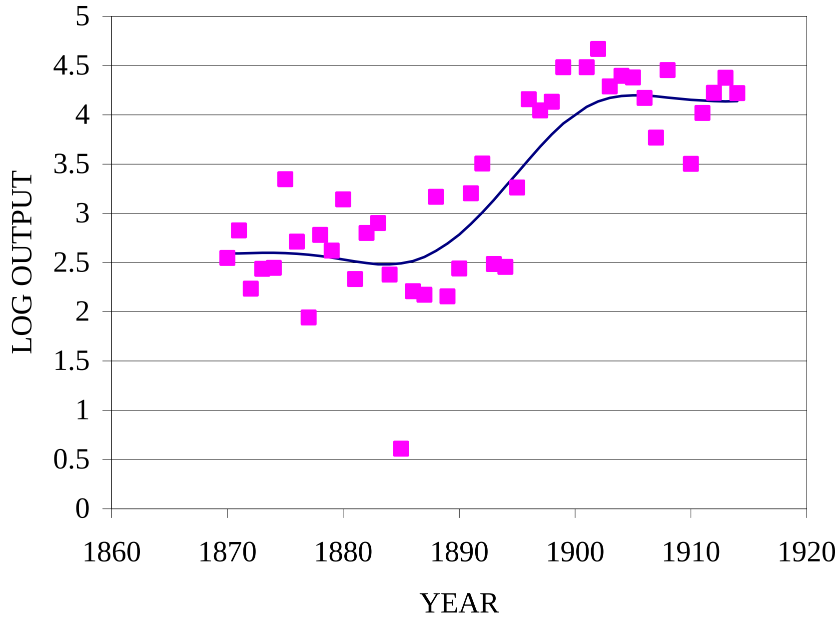

Figure 5 Actual and fitted log output of wine for Casanova (Cerbaia)

Tables 1, 2 and 3 give the estimated risk measures $\hat{s}^{c}_{pf}$ of the pseudo-returns on each crop, separately for each *podere*. The crops included in these tables are only those for which an output is recorded in at least half of the 45 years covered by the sample period.

Table 1 Standard deviations of estimated returns on crops for the plots of the Cerbaia *fattoria* (non-parametric trend estimates)

	Asciano	Casanova	Castellina	Colombaio	Cerbaiola	Chiusino	Poggiarello	Chiusa
Wheat	0.206	0.201	0.222	0.237	0.350	0.497	0.257	0.244
Broadbeans	0.500	0.549	0.536	0.529	0.706	-	0.464	0.578
Vetches	0.625	0.616	0.500	0.571	0.724	-	0.473	0.602
Oats	0.660	0.522	0.340	0.507	0.679	-	0.458	0.526
Beans	0.760	0.578	0.580	0.557	0.742	-	0.467	0.640
Maize	0.594	0.403	0.463	0.527	0.561	-	0.336	0.415
Wine	0.552	0.492	0.565	0.369	0.463	-	0.439	0.412
Oil	-	0.876	0.694	0.668	0.845	-	0.888	0.952
Wool	0.336	0.234	0.260	0.294	0.523	-	0.167	0.178
Cheese	-	-	-	0.447	-	-	0.280	-
Silk	0.373	0.634	0.505	0.466	-	-	0.499	-
Chestnuts	0.896	0.929	0.990	0.918	0.906	-	1.002	1.004

Table 2 Standard deviations of estimated returns on crops for the plots of the Macereto *fattoria* (non-parametric trend estimates)

	Macereto	Palazzo	Palazaccio	Terre a Mano	Barottoli
Wheat	0.795	0.671	0.693	0.499	0.202
Broadbeans	1.201	1.037	1.300	1.413	0.661
Vetches	0.845	1.094	1.183	-	0.647
Oats	-	1.225	-	-	0.723
Beans	0.965	1.271	0.911	-	0.748
Maize	0.827	0.833	0.826	-	0.383
Wine	1.040	0.841	1.023	0.821	0.528
Oil	0.908	-	-	-	-
Wool	0.872	1.277	1.147	-	0.436
Hemp	-	0.814	0.979	-	0.547
Cheese	-	-	-	-	0.465
Silk	0.682	1.015	1.653	1.789	0.367
Chestnuts	0.845	-	-	-	-

Table 3 Standard deviations of estimated returns on crops for the plots of the Poggio le Rose *fattoria* (non-parametric trend estimates)

	Casanova	Pozzo	Poggio le rose
Wheat	0.187	0.205	0.298
Broadbeans	0.519	0.594	0.670
Maize	0.569	0.467	0.545
Wine	0.545	0.508	0.685
Oil	1.396	1.261	1.069
Hemp	-	0.408	-
Silk	0.589	0.954	0.277

The first obvious conclusion that emerges from these estimates is that risk varied enormously across crop types. In particular tree crops (wine, oil and chestnuts) were clearly associated with high levels of output risk. If we re-do the analysis for two composite crops: tree crops and all other crops and then calculate output-weighted averages of the $\hat{s}^{c}_{pf}$ across all *poderi*, the result is an average risk index for tree crops roughly double the size of that for non-tree crops (table 4).

Table 4 Standard deviations of estimated returns on tree crops and non-tree crops (non-parametric trend estimates)

	Tree crops	Non-tree crops	All crops
Estate level[1]	0.328	0.149	0.150
Fattoria level[2]	0.437	0.196	0.202
Podere level[3]	0.571	0.295	0.276

[1] output-weighted averages of risk indices for outputs aggregated to estate level
[2] output-weighted averages of risk indices for outputs at the *fattoria* level
[3] output-weighted averages of risk indices for outputs at the *podere* level

Risk also varied considerably across *poderi*, even for the same crop – for instance the risk measure for wheat increases by a factor of four as we go from the least to the most risky *podere.* Unavoidable estimation and specification errors may play some part in this, but the robustness of this finding across the four approaches we have used suggests that it is most likely to be the outcome of differences in micro-climate, soil conditions and farming technique.

A second finding is that riskiness varied substantially across *poderi*, but was everywhere extremely high for tenants and considerably lower at the *fattoria* and estate level. The landlord thus appears to have pursued a successful diversification strategy in a risky region, and yet the very fact that he was able to do so raises important questions about the role of risk in tenure choice in this case. High output variability, once the trend is factored out, is detected in the sample both over time within a given plot, and in the same year across different *poderi*. Croppers' performance, in other words, was not observable *ex post* from the harvest: the level of noise was simply too high. The concept of a 'normal' year is elusive in this context, as is the idea of using other croppers' harvest as a benchmark to judge the effort put in by any given individual. This is made clear by inspection of the correlations between returns on different crops within the same *podere*, and for the same crops across different *poderi*. There are too many of these correlations for us to reproduce them in full, but tables 5-7 are typical. They show the main between-crop correlations for one representative *podere* (Casanova) and the between-plot correlations for two important crops: wheat and wine. The remarkable feature of these tables is how low the correlations are. On the basis of these, it would be very difficult indeed to judge the performance of one tenant by comparing his output with that of another.

Table 5 Correlations between crop returns for the Casanova *podere*

	Wheat	Broadbeans	Vetches	Oats	Beans	Maize	Wine	Oil
Wheat	1.00	-0.03	0.07	-0.00	0.28	0.14	0.29	-0.13
Broadbeans	-0.03	1.00	0.16	0.02	0.08	0.15	0.04	0.17
Vetches	0.07	0.16	1.00	-0.16	0.25	0.03	0.08	0.21
Oats	-0.00	0.02	-0.16	1.00	0.07	0.05	-0.15	-0.00
Beans	0.28	0.08	0.25	0.07	1.00	0.19	0.26	0.11
Maize	0.14	0.15	0.03	0.05	0.19	1.00	-0.17	0.15
Wine	0.29	0.04	0.08	-0.15	0.26	-0.17	1.00	0.03
Oil	-0.13	0.17	0.21	-0.00	0.11	0.15	0.03	1.00

Table 6 Correlations between returns on wheat for various *poderi*

	Asciano	Casanova	Macereto	Barottoli	Pozzo	Poggio
Asciano	1.00	0.78	0.02	0.55	0.25	0.33
Casanova	0.78	1.00	0.06	0.34	0.36	0.32
Macereto	0.02	0.06	1.00	0.20	0.09	-0.05
Barottoli	0.55	0.34	0.20	1.00	0.22	0.21
Pozzo	0.25	0.36	0.09	0.22	1.00	0.38
Poggio	0.33	0.32	-0.05	0.21	0.38	1.00

Table 7 Correlations between returns on wine for various *poderi*

	Asciano	Casanova	Macereto	Barottoli	Pozzo	Poggio
Asciano	1.00	0.88	0.44	0.73	0.70	0.54
Casanova	0.88	1.00	0.41	0.66	0.54	0.59
Macereto	0.44	0.41	1.00	0.39	0.24	0.26
Barottoli	0.73	0.66	0.39	1.00	0.53	0.41
Pozzo	0.70	0.54	0.24	0.53	1.00	0.62
Poggio	0.54	0.59	0.26	0.41	0.62	1.00

The scope for diversification of output risk is summarised in figure 6, which shows risk measures for crop portfolios at the level of individual *poderi*, *fattorie* and the estate as a whole. To do this, we have estimated the portfolio share vector, m, in each case as the vector of output value shares. Elementary portfolio theory suggests that high risk should be accompanied by high expected return, so the use of output shares, rather than initial investment shares (which are not observed), gives slightly too high a weight to riskier elements of each portfolio.[2] Nevertheless, unless risk premia were very large indeed, the bias introduced by this will be small, and we believe that figure 6 gives a reliable qualitative picture of the way that diversification worked in practice. The scope for diversification was clearly very large. From the *podere* to *fattoria* level, portfolio risk measures tend to fall significantly, the largest declines being 50% or more. From the *fattoria* to estate level, there are further falls in riskiness of up to 40% or so.

We have said that the landlord seems to have successfully diversified at the estate level. He also acted as a banker, smoothing out consumption for different people at different times. While we do not know tenants' net credit position for these years, there is strong evidence that sharecroppers were often net lenders to the estate in which they worked, at times for considerable sums (Pasolini 1890; Tassinari 1914; Fattori 1973; Giacinti 1974; Violante 1983; Nucci and Pellegrinotti 1994). The complexity of the contract clearly emerges from these considerations. Incentive compatibility in a situation characterised by strong moral hazard and metering uncertainties, risk sharing on an estate level with cultivation prone to dramatic output swings, credit screening (the landlord had informational advantages in credit provision, as well as being able to resort to credible threats, that an external moneylender lacked) and with it the replacement of incomplete or poorly functioning markets, all have been recognised in the theoretical literature (Singh 1989). What is important here is that they clearly emerge from our analysis of crop risk

[2] It is possible to invent methods for 'eliminating' this bias. For example, if one believed that there were sufficiently good markets for risky assets at the time, one might use the capital asset pricing model to estimate β coefficients for each crop on each *podere*, and use these to infer the the underlying investment shares, given assumptions about the safe rate of interest and the 'market' risk premium. However, this may be strteching credulity rather too far, and is in any case unlikely to change figure 6 in any important qualitative sense.

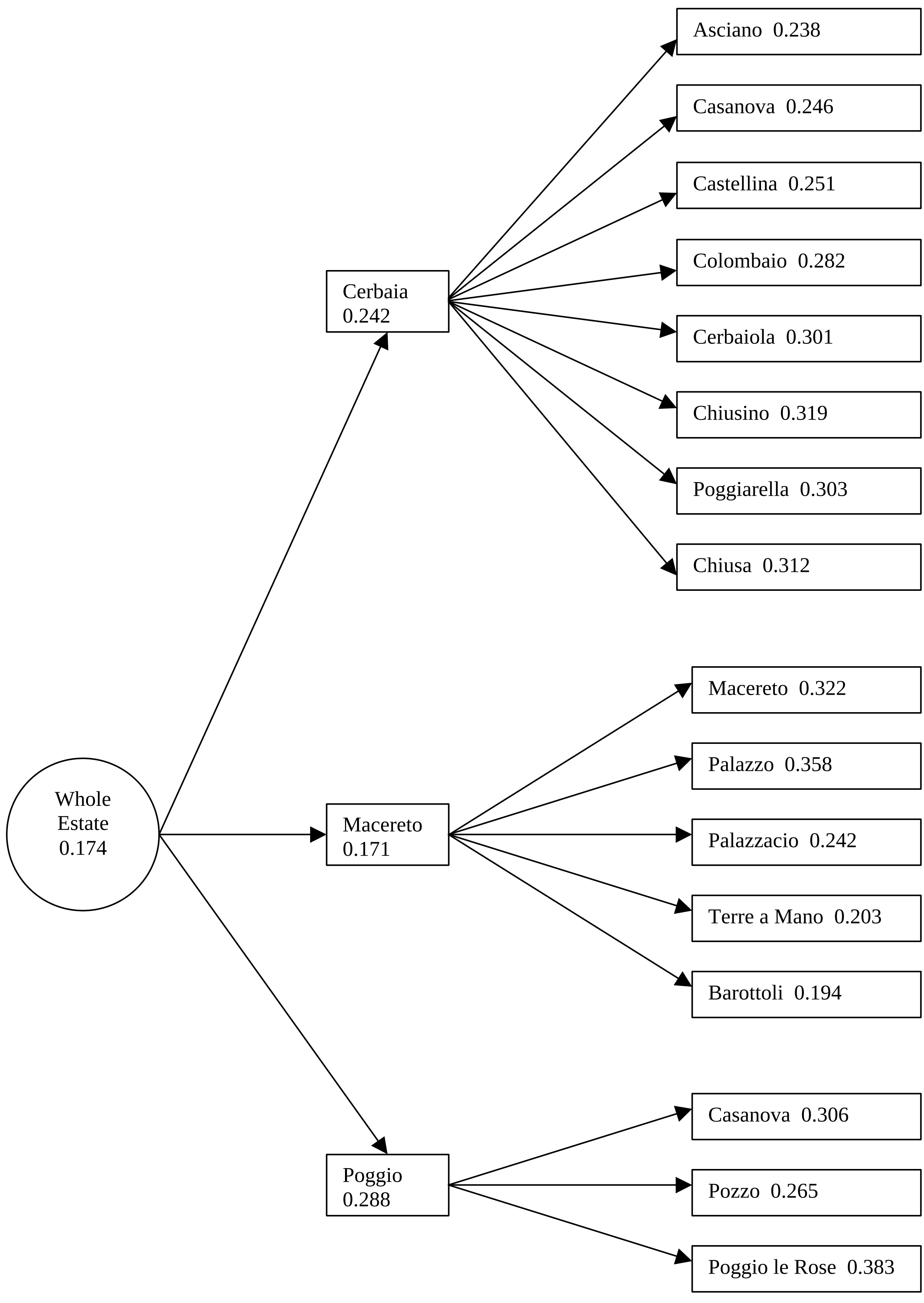

Figure 6 Diversification of risk at plot, fattoria and estate levels (non-parametric trend estimates)

Conclusions

There are many models of farm tenure and consequent tenant behaviour. At least three factors are critical in this literature. One is the incentive properties of alternative contract types, through the different implicit output taxes they embody. A second is the control of long-lived assets such as vines and trees, in situations where equally long-lived tenancy contracts cannot be enforced, and where the objectives short-term production and long-term maintenance of the capital assets may be in conflict. A third is output risk, and the scope that landlords have to control their own risk by diversification of their crop portfolios, and to share risk with tenants by means of formal crop sharing or informal insurance and banking activities.

In this paper, we have tried to assess the scale and nature of output risk in the context of 19th and early 20th century Tuscan farming (mainly conducted under crop-sharing tenure). Our findings make it very clear that risk was an extremely important factor; that landlords were in a very advantageous position relative to their tenants in terms of risk; that risk sharing is likely to have been a major factor underlying the use of sharecropping tenancy. This last point is particularly so in the case of tree crops, for which risk levels were extremely high.

The large random component of output would also have had another effect that is important for theories of tenure choice. The apparently random fluctuations in output between and within *poderi* and crop types must have made it very difficult for landlords to identify 'shirking' tenants without the most careful and costly monitoring of the *process*, as well as the output, of production by individual tenants. This creates a presumption in favour of incentive-compatible tenancy contracts that reduce the required extent of monitoring.

It is always going to be difficult to separate these and other influences on the contract choice decision. We believe that a reasonable view is emerging: that sharecropping was an arrangement that may have satisfied a number of objectives simultaneously. It allowed vulnerable tenants to share output risks with landlords, whilst setting tenants' work incentives at a point which encouraged more effort than a wage contract would have done, but gave less encouragement to short-term over-production from long-lived tree crops than rental contracts would have done. Sharecropping contracts also had the advantage of removing from landlords the necessity of estimating the optimal rent to charge – something that would have been difficult, given the large variations in output levels across individual *poderi*.

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